function properly. Ports should create incentive programs for the replacement or retrofit of older trucks to carry out these measures. Ports can reduce emissions further still by enforcing limits that require reduced engine idling.

Purchase New, Cleaner Trucks to Replace Pre-1984 Models

This program would encourage independent truck owners who perform the majority of their contractual work at a given port and operate pre-1984 model year trucks to voluntarily replace them with 1994 model year or newer trucks. The measure is an extremely cost-effective way to reduce truck emissions at ports, particularly because most truck models from 1983 and earlier have no emissions controls whatsoever.

Newer vehicles would also be equipped with an appropriate after-treatment system to further reduce particulate matter (PM) emissions and air toxics, described in more detail in the cargo-handling equipment section, with the priority of replacing pre-1984 heavy trucks. After identifying the applicant pool with the oldest heavy trucks, preference should be given to applicants willing to replace their trucks with the cleanest available options. Incremental funding should also be disbursed for low-sulfur diesel to those applicants who opt to install a higher-efficiency DPF system on their new trucks until mid-2006, when federal requirements for low-sulfur diesel phase in. The program should encourage the replacement of the oldest vehicles with the newest, cleanest engines, including after-treatments.

A recent CARB study concluded that alternative diesel fuels provide relatively cost-effective reductions of PM, NO_x, and petroleum use.

Pollutants Reduced Similar to the recommendation to purchase new cargo-handling equipment, this measure would reduce toxic diesel PM, NO_x, and other pollutants associated with diesel engine exhaust.

Unit Cost Used model year 1994 heavy-duty diesel trucks cost $25,000 to $45,000.[79]

Cost-Effectiveness Focusing on the replacement of the oldest and dirtiest trucks in the port with newer used trucks can provide a cost-effective means of reducing both NO_x and PM emissions. On average, replacing a pre-1984 engine with a post-1993 engine will result in an average cost-effectiveness of $8,200 per ton of NO_x reduced and $28 per pound of PM reduced. In addition to these significant NO_x and PM benefits, the strategy of replacing older trucks and employing DOCs or DPFs on the newer trucks results in an 82 to 96 percent overall PM emission benefit (including the benefit of the new engine). The DPFs provide greater PM emission reductions (96 percent), for a total unit price, including fuel, of $31,000 to $53,500.

One benefit not included in cost-effectiveness estimates is the increased fuel efficiency of new engines. Mechanical engines, typical of pre-1991 model years, in general, have much lower fuel efficiencies than electronically fuel-injected engines: two to three miles per gallon versus three and a half to four miles per gallon for a new engine.[80]

EXAMPLES ▶ Although only in its second year, the Gateway Cities program has proved very successful in Southern California as a way to retire pre-1984 heavy-duty trucks. The program is funded mainly by a coalition of approximately 30 local cities and government agencies. The program has amassed roughly $14 million to remove aging and largely uncontrolled diesel trucks operating in the port area with 1994 model year or newer diesel-powered trucks. And the program has allocated approximately $4 million for aging heavy-duty trucks that meet certain conditions and generally operate in and around the Port of Long Beach as well as the surrounding area.[81] The China Shipping settlement mandated the Port of Los Angeles to provide an additional $10 million, earmarked specifically for the replacement of diesel trucks servicing the Port of Los Angeles.

Regularly oversubscribed, the program shares expenses with the recipient trucker. More than 200 pre-1984 model year trucks serving the ports of Long Beach and Los Angeles have been retired and replaced with newer, lower-emitting trucks.[82] So far, an estimated 0.8 tons of NO_x and 0.2 tons of PM will be reduced per year for each truck over their next five years of operation, totaling more than 160 tons per year of NO_x and 40 tons per year of PM reductions.[83] Of the total to date, more than 80 of the trucks have been replaced with funds from the China Shipping settlement.[84] Although not yet implemented, the Gateway Cities program also includes potential elements to (1) install diesel DOCs on the "modernized" trucks of independent owner operators and (2) install DPFs or other after-treatment devices on appropriate fleet-operated trucks that would require the use of low-sulfur diesel at 15 ppm.[85]

Focusing on the replacement of the oldest and dirtiest trucks in the port with newer used trucks can provide a cost-effective means of reducing both NO_x and PM emissions.

DISCUSSION ▶ A number of programs, including the Gateway Cities program just discussed, use variations of this strategy to reduce NO_x, PM, and toxic pollution emitted by aging diesel trucks in regular operation at ports.

AB 2650, a relatively recent California law introduced by Assembly Member Alan Lowenthal, will generate penalty funds from marine terminals in major metropolitan areas that allow trucks to idle for more than 30 minutes. The funds will be used to replace aging diesel trucks that operate in and around the port area with 1994 model year or newer trucks equipped with after-treatments that can achieve a 90 percent reduction, or 0.01 grams per brake horsepower-hour (g/bhp-hr) PM standard. Such alternative fuels as natural gas would also be funded under this program.

Many other programs in the United States offer incentive funding for the replacement of older vehicles, equipment, or engines. The Carl Moyer Program, also in California, can be used for incentive funding for cleaner new purchases. Many metropolitan areas have their own programs, through local branches of the U.S. Department of Energy's Clean Cities Program, local air quality management districts, or regional government authorities. Two other notable programs are the Texas Emission Reduction Plan (TERP) and the Sacramento Emergency Clean Air Transportation (SECAT) Program.[86]

These types of programs can be fairly labor- and resource-intensive to administer. However, the potential emission benefits are large. The cost-effectiveness of this step is slightly higher than that of other control strategies for heavy-duty trucks. However, for very old trucks that smoke, called gross polluters, the step is competitive with others, particularly because old trucks have few retrofit options, none of which reduce as much pollution. Additionally, even though cost-effectiveness assessed for the cost of full replacement is high, we recommend a partial subsidy, which would greatly improve cost-effectiveness.

Programs must be tailored to the age and type of truck fleet serving a specific port. For example, roughly 10 percent of trucks serving the Port of Oakland are pre-1987 model year, all of which should be eligible for replacement under this type of program.[87] Roughly one-third of trucks serving the Port of Oakland are from the 1987 through 1993 model years. A repower, instead of a replacement, program would be better suited for this middle-aged group of trucks.

As with the SECAT and Gateway Cities programs, contracts must be designed so that new truck purchases funded by this program stay in service in a specified geographic area for a specified time. Without contractual obligations tied to the funding, "drayage" truckers, those hauling loads on short trips, may be tempted to use their more reliable new rigs on long-haul business instead of remaining in local service to the port. In that event, new owner/operator trucks, operating old rigs on thin margins, could easily take up the slack, again increasing emissions at and near the port.

Retrofits for Existing 1984 Model Year and Newer Vehicles

This program would encourage, but not require, independent truck owner contractors who perform the majority of their contractual work at the port and operate a 1984 or later model year truck to install an appropriate after-treatment system to reduce emissions. The approach would be very similar to the previously described approach of replacing older trucks with newer models, allowing incentive funding for after-treatments on 1984 and newer trucks.

After-treatments, such as diesel particulate filters (DPF) and diesel oxidation catalysts (DOCs), can reduce diesel exhaust emissions by varying amounts depending on the specific technology employed. The CARB and the EPA have so far verified five DPF emission-control devices for 1994 model year or newer heavy trucks, as well as many other retrofit devices.[88] Of all the retrofit devices available, DOCs have the longest history of certification and use on both diesel and natural gas-powered heavy-duty vehicle configurations. Where trucks cannot be replaced with 1994 or newer engines, retrofits with DOCs would be required.[89]

Where compatible, incentives should favor the use of the cleanest possible retrofit controls available. Extra fuel stipends should be offered to cover the incremental

Diesel particulate filters can be put in place of the muffler on modern trucks, reducing particulates in exhaust by more than 85 percent.

JOE KUBSCH/MECA

cost of low-sulfur diesel for after-treatments that specify the cleaner fuel. This extra incentive should expire in mid-2006, when federal requirements for low-sulfur diesel phase in. All applicants who receive awards from the proposed measure should be required to attend free maintenance and training courses to help ensure proper care for the vehicle and after-treatment systems.

Pollutants Reduced Table 2-12 lists the various after-treatment technologies available, estimated pollutant reductions, fuel requirements, and fuel penalties.

Unit Cost Cost estimates for retrofit controls are also listed in Table 2-12. Many of these controls require low-sulfur diesel, which costs approximately 5 to 20 cents more per gallon than regular on-road grade diesel, depending on location.[90]

Cost-Effectiveness Cost-effectiveness for retrofitting trucks varies widely, depending on the number of miles driven, the availability and cost of fuels and controls, and the age of the retrofitted truck. Table 2-13 summarizes the ranges of cost-effectiveness for various retrofits that can be applied to off-site container trucks.

Both of the NO_x control strategies—NO_x catalysts and EGR—are relatively competitive in terms of cost-effectiveness. But the range of cost-effectiveness for PM

TABLE 2-12
Pollutants Reduced by Various Retrofit Technologies

	PERCENTAGE REDUCTIONS						
Technologies	**NO_x**	**PM**	**CO**	**VOC**	**Fuel Sulfur Tolerance**	**Fuel Penalty**	**Cost**
Active Diesel Particulate Filter (DPF) & Lean NO_x Catalyst (LNC)[a]	25	85	60–80	40–60	Up to 15 ppm	3–7%	$15,000–$18,000
Passive Diesel Particulate Filter (DPF)[b]	—	85	60–90+	60–90+	Up to 15 ppm	2–4%	$5,000–$7,000
Flow-Through Filter (FTF)[c]	—	> 40	> 40	> 40	Up to 500 ppm	10%	$700–$7,000, most likely ~$1,500–$2,000
Diesel Oxidation Catalyst (DOC)[d]	—	25	40–90	40–90	Up to 500 ppm	0–2%	$1,000–$3,000
Exhaust Gas Recirculation (EGR)[e]	40–50	N/A	N/A	N/A	Up to 500 ppm	0–5%	$13,000–$17,000
Lean NO_x Catalyst[f]	10–20	N/A	N/A	N/A	Up to 250 ppm	4–7%	$6,500–$10,000

Sources: *EPA Technical Summary of Potential Capabilities of Currently Available Retrofit Technologies*, www.epa.gov/otaq/retrofit/retropotentialtech.htm; CLeaire; Clean Air Systems; CARB, *Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Airborne Toxic Control Measure for in-use Diesel Fuel Transport Refrigeration Units (TRU) and TRU Generator Sets, and Facilities where TRUs Operate*, Oct. 28, 2003 and *Diesel Risk Reduction Plan*, Oct. 2000; Memo from Dale McKinnon, Manufacturers of Emission Controls Association, Dec. 5, 2000; and MECA, *Retrofitting Emission Controls on Diesel-Powered Vehicles*, March 2002.

Note: This table differs from the table listing retrofit technologies for off-road applications, which often have different duty cycles and activity factors.

a NO_x and PM reductions as verified by CARB; CO and VOC reductions as reported by CLEAIRE, currently the only manufacturer that has verified this type of retrofit technology.
b Verified DPFs are prone to produce more nitrogen dioxide, as its creation is required for proper regeneration of the system. CARB believes the NO_x increase is offset by NO_x benefits achieved by the DPF systems.
c FTFs are not yet commercially available; they are expected to complete CARB verification in 2004.
d DOCs may achieve higher PM reductions, especially with very low sulfur fuels; however, they are verified only at 25% by CARB.
e EGR increases PM emissions slightly, and therefore should not be used without a PM control.
f LNCs are not yet commercially available alone, although they are available as a package with a DPF or DOC. The cost of DOC-LNC retrofit is roughly $10,000.

TABLE 2-13
Ranges of Cost-Effectiveness of Various On-Road Control Strategies

Control Strategy	NO_x (Per Ton)	PM (Per Pound)
Active DPF and NO_x Reduction Catalyst[a]	$ 6,000–35,700	$ 78–117
Passive DPF[a]	N/A	$ 31–57
Diesel Oxidation catalysts (DOC)[b]	N/A	$ 5–35
Exhaust Gas Recirculation (EGR)[a]	$ 3,300–37,000	N/A
Lean NO_x Catalyst[a]	$ 4,100–43,500	N/A
Flow-Through Filter[b]	N/A	$ 2–51

Assumptions: (1) Pollutant reduction percent and costs were taken from Table 2-12. (2) Baseline emission factors taken from 2003 Carl Moyer Guidelines, Table 2.6 & 9.3. (3) Project life ranges from 7 to 15 years, per Carl Moyer Guidelines, Sept. 2003, p. 23. (4) The incremental cost of ULSD is based on [fuel cost per gallon] x [annual mileage/ 6 mpg]. The best cost scenario was estimated at $0.05/gallon, and the worst case scenario was estimated at $0.20 per gallon. (5) Annual vehicle mileage was assumed to range from 30,000 to 65,000 miles.

a These retrofits were assumed to apply to MY 1994 trucks for the best case and 2004 worst case.
b These retrofits were assumed to apply to MY 1984–1990 trucks for the best case and 1991–1993 worst case.

controls varies considerably because control strategies vary with the age of the truck. For example, both DPF options appear much less cost-effective because they must be applied to 1994 and newer trucks (due to engine compatibility), which are much cleaner than earlier models. The result is that control strategies, such as DOCs and flow-through filters, can reduce a smaller percentage of PM, but from much dirtier older trucks, therefore yielding greater overall PM reductions.

EXAMPLES ▶ The Port of Oakland is currently designing an incentive program for off-site trucks. The $2 million program appears to be focused on incentives for new purchases and retrofits and is slated to begin in 2004.

DISCUSSION ▶ The incentive programs noted earlier—Gateway Cities, SECAT, TERP, and Carl Moyer—also serve as precedents for retrofitting diesel trucks. In addition, two other regional California programs, funded by vehicle registration fees, offer similar incentive funding. The mobile source air pollution reduction review committee's MSRC discretionary funds receives 30 percent of funds collected each year from a $4 surcharge on vehicle registration in the Los Angeles area. MSRC incentive funding targets programs that reduce mobile source emissions, including alternative-fuel infrastructure, alternative-fuel school buses, and cleaner on- and off-road heavy-duty vehicles. The San Francisco Bay area transportation fund for clean air also disburses roughly $20 million per year for the cleanup of existing vehicles and equipment and funds cleaner new purchases.

After-treatments should be tailored to the local air shed, focusing on more expensive NO_x reductions in urban areas suffering from smog. PM reductions remain a priority in every air shed, because PM, especially diesel PM, has a severe effect on local health. We do not recommend the use of after-treatments that require low-sulfur diesel where appropriate fuel is not available, except in the case of centrally fueled fleet applications, where cleaner fuel can be delivered. When low-sulfur diesel becomes available nationwide in mid-2006, these sensitive after-treatments can be more widely used. Unfortunately, in the absence of available low-sulfur diesel, PM controls are limited to DOCs and flow-through filters, which are much less efficient at removing PM.

The more efficient DPF after-treatments are also limited by other factors. They can be applied only to 1994 model year or newer heavy trucks, are vulnerable to failure if maintenance is not timely or if vehicle use does not consistently generate high enough temperatures, and misfueling with diesel fuel containing sulfur levels greater than 30 ppm is a possibility—an error that could impair performance and contaminate and destroy DPF systems.

Many new technologies are emerging, providing more options for different levels of PM and NO_x reductions in older versus newer model year vehicles with varying fuel types. As California continues to implement a series of diesel PM control rules, we expect more control technology options to be verified and become available for use nationwide.

Finally, it should be noted that we do not recommend repowers in this measure because of the logistical constraints on owner/operator truckers and small truck fleets. Repowers are a cost-effective pollution control measure, when truck owners or operators can afford to have their trucks out of service for several weeks while the engines are replaced. However, that may not be feasible for many trucks serving marine terminals because time in service for each individual truck is so important. Large fleets, such as terminal tractors (see cargo-handling equipment covered in previous section), appear to be better equipped to cycle a few vehicles out of use for a few weeks at a time.

The Port of Oakland has identified a local trucking company with a centrally fueled fleet that will demonstrate the use of diesel emulsions.

Cleaner Diesel Fuels

This measure is appropriate for centrally fueled truck fleets. A fleet manager would have to commit to a cleaner fuel and arrange for on-site delivery and fueling. The various available clean fuels, pollutant reductions, costs, and other effects are described in the cleaner diesel fuels discussion for existing equipment. The fuels listed in that measure are all appropriate for use in off-site trucks and cargo-handling equipment.

The Port of Oakland has identified a local trucking company with a centrally fueled fleet that plans to demonstrate the use of diesel emulsions. Some of the company's trucks will also have DOCs installed, followed by limited testing to compare the performance of trucks with and without DOCs. This demonstration has only recently begun, so impact estimates are premature.

Reduced Idling

Ports should restrict idling inside and outside the terminal to no more than 10 minutes for all container trucks. Idling limits should apply in all terminal areas throughout the port, as well as in queuing areas near entry gates. Marine terminal operators (MTO) and port authority personnel should be responsible for ensuring that idling limits are met, but enforcement should be conducted by the port, air quality agency staff, or such local officials as police officers. Finally, MTOs must provide sufficient electrical power hookups for refrigeration units and any other heavy-duty truck power needs in all terminals and queuing areas.

Finally, MTOs should be responsible for ensuring that lines do not form inside the terminal instead of outside the gates—a problem some drivers have reported at the ports of Oakland and Los Angeles. It is more difficult to enforce idling limits when long lines of trucks are waiting inside the terminal because they must constantly start up to advance the line and compete for attention in receiving or dropping off their loads.[91] MTOs should consider implementing a scheduling system so that drivers arrive at appointed times and that containers are ready when drivers arrive.

One promising solution is a statewide mandate requiring idling restrictions, with enforcement through local regulatory agencies. However, without a regulation in place, this measure should still be encouraged by individual ports.

At the Port of Los Angeles, 10-minute idling restrictions would translate to more than 800 tons per year of NO_x reductions, more than 14 tons per year of toxic PM reductions, and reduced emissions of the primary greenhouse gas, carbon dioxide, of more than 46,000 tons per year.

Pollutants Reduced A 10-minute idling limit could save hundreds of gallons of fuel annually for each truck that regularly visits the port. In addition, it would likely reduce emissions of priority pollutants by dozens of tons. The fuel savings and emission reductions are directly related to the reduction in idling time. The pollution reductions are most significant for diesel PM and NO_x; however, reductions in other pollutants, such as CO_2, CO, SO_2, and VOCs provide additional benefits.

Emission rates during idling do not consistently go down with newer model years; therefore, new trucks must also adhere to the idling limits as long as they are powered by fossil fuels. Although VOC emissions during idling steadily decline with newer model year vehicles, NO_x, CO, and CO_2 have increased with newer models.[92]

Unit Cost Some costs are associated with this measure. Each terminal operator in a port would have to hire personnel to monitor compliance. In addition, terminal operators would need to post signs and train both their new and existing personnel for enforcement. This could cost terminal operators on the order of $100,000 a year (possibly more during the first year, but subsequent years will cost much less).[93]

Cost-Effectiveness At the Port of Los Angeles, reducing idling could reduce more than 800 tons of NO_x every year, for an average cost-effectiveness of $990 per ton. Compared with other measures, that is an extremely cost-effective pollution control measure. Moreover, that estimate does not include all of the other pollutants that would be reduced by this measure, including the reduction of 14.4 tons of toxic diesel particulate and more than 46,000 tons of greenhouse gases.

In addition, this measure would result in significant cost savings from the reduced use of fuel—more than 4 million gallons at the Port of Los Angeles, for example. At this writing, the U.S. Department of Energy reports that a gallon of diesel in the United States costs on average $1.50, so the millions of gallons of diesel fuel consumed annually that this measure would reduce could translate to millions of dollars in collective savings to port truckers.[94]

Finally, truck owners should also benefit from reduced maintenance on their trucks. Experts estimate that engine wear on trucks due to idling for one hour per day is the equivalent of 6,400 miles of travel annually. That is roughly equivalent to an additional $300 per year in added maintenance on a vehicle.[95]

EXAMPLES ▶ California implemented a statewide idling law in 2003 (see Chapter 3), limiting truck idling at ports in major metropolitan areas to 30 minutes. The law appears to have significantly reduced idling outside of port terminals, but some truck drivers at the ports of Oakland and Los Angeles report long lines and idling inside terminals, thus offsetting the benefits. Other ports, including the Port of Seattle, are beginning to post no-idling signs and implement idling restrictions, but enforcement is questionable.

DISCUSSION ▶ The enforcement of an idle-reduction measure should significantly reduce pollution, result in substantial fuel savings, and reduce noise pollution around the terminals and in local neighborhoods. The cost-effectiveness of this measure rivals the least-expensive emission reduction strategies available today. The benefits are enormous to the terminal operators, truckers, and the community. The one serious drawback is that enforcement

PARKING PLACES WITH AMENITIES

At least one company is developing travel center electrification products intended to provide in-cab heating and air conditioning for heavy diesel freight-hauling trucks, where they would otherwise idle for extended periods. Advanced travel center electrification systems provide each installed parking space with an individual heating, ventilation, and air conditioning (HVAC) unit mounted outside and above the truck. With the swipe of a credit card, a console unit is tethered to the HVAC and mounts into a truck's cab window, delivering heat or air conditioning along with television, Internet, local phone connections, and a 110-volt outlet for appliances. Outside, separate plugs power refrigerated trailers and engine block heaters.

This type of system can be used at port facilities, truck stops, terminals, border crossings, and many other areas. Systems are already in place in 11 travel centers or parking facilities in New York, Texas, California, Georgia, Arkansas, and Tennessee, with many more locations planned throughout the country.

The electrification system benefits community members, truckers, and entrepreneurs by

- Reducing toxic diesel emissions
- Eliminating idling noise nuisance to nearby community
- Saving truckers fuel and the extra costs of engine wear associated with prolonged idling while parked
- Providing added revenue to local commercial travel center or parking site owners
- Increasing driver comfort and rest

More than 250 trucking fleets provide their drivers with discounts to these plug-in facilities.

Source: www.idleaire.com.

may be difficult for port and MTO personnel unaccustomed to taking on enforcement roles.

Use of appointment, scheduling, or other truck or container management systems would also help reduce idling. Ultimately, however, enforcement is needed to curtail idling in many instances. For example, residents in neighborhoods close to terminals often complain that trucks idle outside terminal gates through the night. Lengthening gate hours may also disturb nearby communities, encouraging more traffic early in the morning or late at night. Ports, terminal operators, drivers, and community

RAIL VERSUS ROAD

Freight companies face a choice when shipping their goods to or from coastal ports: Should they send freight by rail or by road? To minimize emissions, fuel consumption, cost, accidents, and traffic congestion, the resounding answer is rail, according to a number of studies.

A study jointly commissioned by the Environmental Protection Agency, the Federal Railroad Administration, and the Federal Highway Administration, for example, found that transferring freight from today's average truck fleet to rail would reduce NO_x, CO, PM_{10}, and VOC emissions and that pollution reductions can be realized at even greater rates as more freight is transferred in the future. NO_x emission rates measured in grams emitted per ton-mile (ton-miles measure the movement of one ton of cargo one mile) are three times as high for long-distance freight trucks as for double-stack trains. PM_{10} emission rates can be as much as ten times as high for trucks as for rail, and the release of VOCs from trucks can be an astounding 17 times the rate from rail.

Moreover, case studies in Los Angeles, Philadelphia, and Chicago have shown that truck emissions make up a disproportionately high percentage of total regional transportation emissions of NO_x, VOCs, and CO. For example, in Chicago, trucks account for only 7.2 percent of all vehicle miles traveled but are responsible for 39.1 percent of all mobile source NO_x emissions and 20.7 percent of total regional NO_x emissions. In the same region, a national rail transportation hub emits only 2.3 percent of total NO_x emissions. Improving emission standards for trucks will eventually narrow the gap between diesel rail and diesel trucks. Therefore, trains must also be cleaned up or switched to electric power instead of diesel fuel, in order to maintain advantages in emission reductions.

Rail also outpaces road in fuel efficiency. For every gallon of fuel, rail lasts 455 ton-miles, whereas trucks last only 105, meaning that trucks burn at least four times as much fuel as rail. Another study found similarly that truck fuel use ranges from 1.4 to 9 times that of rail.

Over and above the significant environmental benefits, rail reduces costs both for freight companies and society.

Private freight transport costs range from 1 to 3 cents per ton-mile for rail freight, whereas each ton-mile costs about 5 to 8.5 cents if delivered by truck. These costs do not include the many external costs left unpaid by trucking companies. For example, the societal costs directly associated with air pollution are estimated as eight times as high for truck use as for rail. Additionally, extra costs are incurred from accidents involving trucks, and a switch to rail could lessen increased roadway congestion, resulting in additional fuel use as well as travel time. One forecast for the Norfolk-Newport News-Virginia Beach area shows that transferring 25 percent of projected 2010 truck traffic to freight would save 69 gallons of diesel fuel and gasoline per capita that year, if increased fuel efficiency and reduced traffic congestion are accounted for. Similarly, citizens of Houston would each save 64 gallons, and New Yorkers would save 46 gallons.

Today, ports can speed the conversion to rail by formulating proactive policies that encourage on-dock intermodal rail and rail infrastructure improvements and discourage existing dependence of freight transport by truck.

Sources: Cambridge Systematics, Inc. (1997), *Air Quality Issues in Intercity Freight: Final Report*, prepared for Federal Railroad Administration, Federal Highway Administration, and Environmental Protection Agency; D Forkenbrock (1998), *External Costs of Truck and Rail Freight Transportation*, the University of Iowa: Public Policy Center, 55 pp. and (2001), "Comparison of external costs of rail and truck freight transportation," Transportation Research, Part A 35:321-337; Air Pollution Prevention Directorate, Environmental Protection Service, Environment Canada (2001), *Trucks and Air Emissions: Final Report*; H Van Essen, et.al. (2003), "To shift or not to shift, that's the question: The environmental performance of freight and passenger transport modes in the light of policy making," CE Delft; T Brown, A Hatch (2003), "Intermodal: on the fast track," available at www.tomorrowsrailroads.com/industry/intermodal.cfm; and W Cox (2003), "Gridlock relief: freight rail's role in reducing gridlock," available at www.tomorrowsrailroads.com/industry/gridlock.cfm.

residents need to work together to find solutions that keep terminals open longer without disturbing local communities.

The creation of extra truck parking with electrical hookups or technology similar to Idle Aire (see "Parking Places with Amenities," page 51) is critical to any comprehensive truck-idling reduction program. Many trucks, especially those traveling long distances, arrive at port terminals during off hours when gates are closed, prompting drivers to leave engines idling while waiting in order to have heat, air conditioning, or other amenities. In addition, many trucks servicing ports carry refrigerated cargo that requires extra engines to keep the cargo cool. These extra refrigeration engines, called reefers, create additional pollution over and above that from the main truck engine. Most, if not all, ports provide reefer hookups into which refrigerated containers may plug. However, it appears that these reefer hookups are not always available to trucks carrying refrigerated containers, especially those waiting outside terminal gates, leading to increased idling. By providing parking areas with electrical power or services so that these trucks can turn engines off, ports can reduce pollution from both reefer and truck engines.

LOCOMOTIVES

Ports should reduce air pollution from switching locomotives by making three major changes: (1) replace or repower older locomotives at rail yards and container terminals; (2) install idling control devices on switching locomotives; and (3) use cleaner fuels such as lower-sulfur diesel fuel or diesel emulsions in locomotives.

Natural gas powered locomotives provide fuel diversity and significantly reduce emissions. However, specialized maintenance facilities are required.

Cleaner New Purchases and Repowers[96]

This measure would require the replacement or repower of older locomotives, both at the container terminals and at other major rail yards serving a port. Appropriate technologies for engine replacements include new, low-emitting engines fueled either by natural gas or other alternative fuels, or hybrid engines relying on battery-electric and turbine power. In particular, the replacement of pre-1973 locomotive engines, or those engines not yet meeting federal standards, with new alternative fuel or electric-hybrid equipment would provide significant emission benefits. This strategy may require the installation of alternative-fueling stations at the associated rail yards and terminals.

This program would target switching locomotives as opposed to line-haul locomotives because they typically idle for long periods, tend to be quite old, and are known as the workhorses in most rail yards. Among the criteria that should be considered in deciding which locomotives to replace or repower are the emission rates of older engines, the hours normally spent running, the age of the engines, and the willingness of the owner/operator to operate in or near a port after replacement of the engine.

Several alternative-fuel and hybrid-electric locomotives are on the market and available for purchase; others are under development. The "Green Goat," a new hybrid electric switching locomotive, retails for roughly half the cost of a new

PUTTING AN END TO EMPTY CONTAINER TRAFFIC

The Port of Oakland is working with a private company to develop software to coordinate truck trips, thus eliminating unnecessary trips and mileage. Truckers usually drive to ports to pick up empty containers, or "empties," take them to the shipper to pick up merchandise, and then make a return trip to bring the full container back to the port for export. Because shippers and trucking companies are often located some distance away from the port, the distance that trucks haul empties to the shipper creates significant air truck miles. These wasted miles lead to extra roadway congestion and pollution and can be eliminated with well-planned coordination.

When complete, the service will allow trucking companies to interchange containers through an Internet site at a virtual container yard, improving productivity and reducing lines at terminal gates. For example, a trucker in Sacramento could go to Stockton to pick up an empty container, get it filled, and go to the Port of Oakland, saving a trip to Oakland to get an empty container. Bill Aboudi, whose 40-truck company was one of three to test the system, says, "It definitely will reduce congestion big time if everybody gets behind it." The system will soon be available for a small monthly fee to the more than 800 trucking firms serving the Port of Oakland.

Sources: Personal communication with Paul Larking, SynchroNet; and Alec Rosenberg, "The SynchroMet service lets trucking companies interchange containers through one Internet site, increasing productivity and trimming waits at terminal gates", *Oakland Tribune*, 23 April 2002.

conventional locomotive and reduces both PM and NO_x by roughly 85 percent (see "The Green Goat," page 57). It uses a 100 horsepower generator, as compared to 2,000 horsepower locomotive engines, to replenish power to a bank of lead-acid batteries, significantly cutting fuel use by at least one-third and also lowering noise. The least-expensive option uses a Tier II certified diesel generator, although natural gas micro-turbines and fuel cell power are also possible.

Pollutants Reduced The emission benefits of this approach are expected to consist of reduced diesel PM, NO_x, and other pollutants. Depending on the technology selected, NO_x emission reductions are generally reported to be between 50 and 85 percent for electric-hybrid or natural gas powered switching engines.

Unit Cost Locomotives used in switching service are generally older units that have been retired from short-line or line-haul service. Depending on the condition of a used locomotive, the resale unit cost can range from $100,000 to as high as $1 million. Currently, it is not possible to purchase a new natural gas locomotive from an original equipment manufacturer. The several projects completed to date where natural gas fuel was used to power a locomotive have been retrofit projects where the existing engine was overhauled and converted to run on natural gas. Cost for such a conversion, including a new natural gas fuel system, ranges from $400,000 to $800,000 per locomotive.

With production volume increases, the new Green Goat hybrid electric switching locomotive is projected to cost $750,000.[97] Other undetermined costs that must also be considered when investing in such a technology include disposal costs for the lead-acid batteries and the replacement costs of the new battery system at the end of its useful life.[98]

Cost-Effectiveness Although alternative-fuel and electric-hybrid locomotives have significant incremental costs, seeking applications with high usage make these projects a cost-effective option for reducing emissions within port operations. Conservative estimates place the projected annual fuel consumption of a switching locomotive at 25,000 gallons of diesel per year. Retrofitting the locomotive with a low-emission LNG engine would reduce NO_x by more than 9 tons per year and PM by more than 300 pounds per year. The average cost-effectiveness of an alternative-fuel switching locomotive is roughly $12,900 per ton of NO_x and $430 per pound of PM reduced.

Projects opting for the electric-hybrid technology can be more cost-effective because the project life would be longer. That is because the units are new and because the percentage of emissions reduced can be greater. Electric-hybrid switch tractors can achieve 85 percent emission reductions, annually reducing more than 11 tons of NO_x and 800 pounds of PM emissions. The average cost-effectiveness is slightly lower than an LNG switcher, or roughly $11,800 per ton of NO_x and $200 per pound of PM reduced.

The average cost-effectiveness of an alternative-fuel switching locomotive is roughly $12,900 per ton of NO_x and $430 per pound of PM reduced.

EXAMPLES ▶ Burlington Northern ran two LNG line-haul locomotives transporting coal inside Wyoming from 1991 to 1995.[99] From 1994 through 1997, several companies demonstrated LNG switching trains in the Los Angeles area. Two of the four LNG switching trains remain in use in local yards; it is unclear why the other two were discontinued, as the demonstrations were successful. A number of LNG locomotive applications are in use abroad as well, including projects in Russia, Germany, Japan, Finland, and the Czech Republic.[100] In the late 1990s, the Napa Valley Wine Train, a passenger train, was converted to CNG. (See "The Green Goat," page 57, for examples of electric-hybrid use.)

DISCUSSION ▶ Natural gas provides fuel diversity. However, because it is lighter than air and therefore rises, modifications to existing maintenance facilities are generally necessary in order to prevent leaks from going undetected. The modifications usually consist of a methane detection system, an improved ventilation system, new lighting, employee training, and containment procedures.

Electric-hybrid locomotives would also save significant amounts of fuel, so cost-effectiveness for this technology is competitive.

Other clean locomotive options are under development. Railpower Technologies Corporation, the company marketing the Green Goat, also has a natural gas locomotive under development. General Motors is working on a fuel cell locomotive, and General Electric is trying to integrate simpler emission reductions into locomotives, including cleaner diesel fuel, regenerative braking, and automatic idling controls.

Although after-treatments are not yet known to be in widespread use on locomotives, the CARB is exploring use on locomotives of some of the same retrofit controls available for other heavy-duty engines. Many of these retrofit controls, such as diesel oxidation catalysts, diesel particulate filters, and selective catalytic reduction, are likely to work well on locomotives with the right grade of fuel. Finally, locomotives could also be fully electrified, an approach used for passenger rail in many locations. Freight rail, however, presents tougher challenges for electrification. The Port of Göteborg, Sweden, is currently investigating this issue.[101]

Idling Controls

All existing conventional locomotive engines should be required to have automatic idling controls installed. An automatic idling control is a device that automatically controls the locomotive engine so that it turns off when not in use and then turns on when the unit is needed, when the system needs to warm up to maintain a certain operating temperature for readiness, or when battery power needs to be replenished. The controls would be installed on any existing diesel locomotives not slated for replacement, with the oldest switching locomotives the priority. Switching trains are generally quite old and dirty and tend to idle about 75 percent of the time, accounting for 27 percent of their total fuel use.[102] Idling controls reduce fuel use and emissions, and cut down on noise. This measure is widely available and has been used successfully in many locations.

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Pollutants Reduced Pollution reductions are most significant for diesel PM and NO_x; however, reductions in other pollutants, such as CO_2, CO, SO_2, and VOCs provide additional benefits. Idling controls also save hundreds of gallons of fuel in addition to the pollution avoided.

Unit Cost Most automatic idling controls for locomotives cost roughly $6,000 to $10,000, with more elaborate devices costing up to $40,000.[103] Locomotive idling controls typically take several days to install—lost time that constitutes a cost.[104]

Cost-Effectiveness Several companies make these controls and claim that the cost is paid back in a year or two through fuel savings. Locomotive idling controls are extremely competitive on cost-effectiveness of emission reductions. The controls can achieve an average of almost 4 tons of NO_x and 270 pounds of PM reductions per year. Cost-effectiveness is on average $3,000 per ton of NO_x reduced and $50 per pound of PM reduced.

EXAMPLES ▶ Under a Canadian-funded freight sustainability demonstration project, Southern Railways of British Columbia installed the ZTR Control System's SmartStart Technology to automatically shut down and restart locomotives on demand.[105] Under a green transport initiative, the EPA created a grant program in 2002 for the demonstration of locomotive and truck idling controls.[106] The EPA cosponsored a successful locomotive idling control project in Chicago more than a year ago with Burlington Northern Santa Fe (BNSF), Wisconsin Southern Railroad, and the City of Chicago.[107] The EPA has also recently funded a similar project in Vancouver, Washington. Several current state implementation plans for complying with federal air quality standards include measures to explore locomotive idling controls.

DISCUSSION ▶ Several companies make these controls in various configurations for different locomotive types. The use of idling control devices can cut down on noise and can result in significant fuel savings. The EPA estimates that 10 percent of all rail fuel could be saved, translating into 366 million gallons and $240 million.[108] Operators of on- and off-site rail yards where port cargo is handled must agree to this measure; however, potential fuel savings would be a substantial incentive in itself.

THE GREEN GOAT

A company based in Vancouver, Canada, has rolled out a hybrid-electric switching locomotive, the Green Goat, that is competitively priced with conventional locomotives. The Green Goat combines a small and efficient 100 horsepower (HP) generator with a custom-made large bank of batteries. Currently the generator is diesel; however, the company is exploring micro-turbine gas and fuel cell options. The 2,000 HP Green Goat, fitted with an auto-shutoff device to reduce idling, achieves fuel savings of at least 30 percent, NO_x and PM reductions of 80 to 90 percent, and reduced operating noise. Because it is digital, remote-control operation can be integrated.

The Green Goat recently finished a one-year demonstration at a Union Pacific rail yard in Roseville, California, and is now in use at the Marine Corps Logistics Base in Barstow. A smaller, 1,000 HP version, called the Green Kid, is being demonstrated at Chevron's El Segundo refinery in Los Angeles. A number of orders for new Green Goats have recently been placed in Texas.

Sources: Simon Clarke, Executive VP Corporate Development, Railpower Technologies Corp., personal communication, December 2002, and Executive Summary document, November 2002, sclarke@railpower.com. Pat Maio, "Train Makers Race Clock to Find Ways to Cut Locomotive Pollution," *The Wall Street Journal*, 23 Oct 2003.

NIGEL HORSLEY/RAILPOWER

Cleaner Fuels

This measure would be appropriate for all centrally fueled switching and short-haul locomotives. A rail company would have to commit to a cleaner fuel and arrange for on-site delivery and fueling; however, in many areas incentive funding may be available. Details on the various clean fuels available, pollutant reductions, costs, and other impacts are in the first section regarding cleaner fuels at the beginning of the chapter. All of the fuels listed in that measure would technically be compatible with locomotives, but diesel emulsions and low-sulfur diesel (15 ppm sulfur) are the two most likely options. These fuels would also allow the use of such after-treatment controls as diesel particulate filters.

STORMWATER POLLUTION PREVENTION[109]

A model aquatic resources protection program for ports should encompass all potential sources of water pollution and other damage to aquatic resources that are associated with port operations, with the exception of industrial-processed wastewater and domestic wastewater that may be generated onshore within port jurisdiction. Although this section does not cover the construction of port facilities, we encourage ports to follow the guidance provided by the EPA and other authorities, because serious water quality problems can occur during construction (e.g., soil erosion and contamination from construction materials and activities).

The principal water quality issues at ports include the following: stormwater runoff; ship liquid and solid waste handling; fueling; activities in, over, or adjacent to water (e.g., dredging, pile driving, ship maintenance); and stewardship of ecological resources under port auspices.

Broadly speaking, these issues divide into two categories: onshore areas (stormwater), and offshore areas (shoreside and harbor).

A model stormwater program for ports should include the most successful, state-of-the-art general stormwater practices applicable to marine terminals. Shoreside and harbor water quality programs should include best practices that have been successfully implemented in the shipping industry. In both cases, the model programs require no new technological advances for effective application.

Port Guidance on Model Programs for Port Tenants

To have an effective program, the port should provide guidance to its tenants, including development of model stormwater programs, oversight of individual terminal programs, inspections of individual terminals to confirm implementation of an acceptable program, and education and training of terminal staff.

Environmental responsibilities at ports are generally split among the port authority body, the port's tenants, contractors for both parties, and visiting ships. It is essential to distinguish these responsibilities for the purpose of identifying where educational efforts for the various parties should be directed. Ultimately, the parties who actually hold government permits are responsible for meeting water quality standards. For stormwater, the port authority is generally a permittee and has the principal responsibility for preparing a stormwater pollution prevention plan (SWPPP). The permits and SWPPPs in some cases cover tenants, whereas in others tenants produce their own SWPPPs under port auspices as co-permittees or as separately permitted entities. It is preferable that port authorities maintain the permit and SWPPP for all facilities, including tenant-operated terminals, to ensure an efficient and effective water quality protection program.

Documenting and Analyzing Potential Water Pollution

Ports should carefully document and analyze potential water pollution problems as a requirement of any comprehensive stormwater plan.

The analysis should map each terminal and describe how runoff flows through the terminal. It should also assess the risks of pollution, prior instances of pollutant spills and leaks, and best management practices (BMPs) that can be implemented to minimize pollutant runoff. Monitoring data should also be collected to determine existing water quality around the terminal.

Developing a Stormwater Program

Each port terminal should develop a stormwater program that includes best management practices for the control of stormwater runoff in operational, source control, and treatment areas.

The plans should establish operational and source control BMPs that prevent the initial development of water quality problems. However, because source controls will not, in general, fully isolate pollutants from the environment, BMPs to capture and treat water pollutants are also necessary. Because treatment can never provide better water quality than prevention, thorough application of the first two categories of preventive BMPs is always preferred.

The following operational BMPs are critical to an effective stormwater program:

A model stormwater program for ports should include the most successful, state-of-the-art general stormwater practices applicable to marine terminals.

Pollution Prevention Personnel Specific personnel should be assigned responsibility for each aspect of the stormwater management program.

Preventive Maintenance A formal program of preventive maintenance should be implemented to avoid equipment deterioration and failure that cause spills and leaks of pollutants.

Good Housekeeping Each facility should adopt a written policy for maintaining a clean facility, including regular sweeping, drain inlet stenciling to prohibit discharge of pollutants into storm drains, employee education about how to maintain a clean facility, employee incentives, and publication of the good housekeeping policy for employees.

Spill Response A clear, comprehensive, organized program to respond properly if and when a spill occurs should include (1) whom to notify, (2) who is in charge, (3) specific instructions for different materials that could be spilled, (4) spill containment procedures,

(5) easy-to-find-and-use spill cleanup kits, (6) procedures for preventing a spill from getting into a drainage system, (7) a disposal plan, and (8) a worker training program.

Illicit Connection and Illegal Discharge Control Each facility should adopt a written program that analyzes the storm drain system to find and remove connections that would introduce harmful non-stormwater (e.g., sewage) discharges into the stormwater system. There should be an ongoing program to avoid such illicit connections and the illegal discharge of wastes into the storm drain system.

Improved Materials and Waste Management Management strategies should be adopted to substitute less polluting products for more contaminating ones and to decrease waste through recycling and reuse of materials.

Inspection An inspection program is a critical component of any stormwater program and should include two components. The first is an annual comprehensive facility compliance evaluation; as part of this evaluation, an experienced supervisory inspector should walk through and evaluate the entire site, review all stormwater documentation, complete a comprehensive checklist designed to ensure that all protocols and stormwater policies are being followed, and follow up on any deficiencies found at the facility. Second, there should be a regular and ongoing program to find potential problems before they occur. Facility staff must be trained to look for deteriorating equipment that may leak or spill and for stormwater control devices that need maintenance.

Ports should carefully document and analyze potential water pollution problems as a requirement of any comprehensive stormwater plan.

Record-Keeping Each facility must implement a comprehensive system for recording and retrieving information gathered from carrying out all aspects of the stormwater management program. Copies of all records should be maintained at the facility and as part of a central port stormwater control program.

Employee Training Proper training is essential for any stormwater management program to be effective. Ports should implement formal and documented training programs for all personnel who perform or supervise any function that could affect runoff water quality appropriate to the level and responsibilities of the employees. For example, outdoor workers might get "tailgate training" to explain why stormwater control is important and how the release of pollution can be avoided in their work. Supervisors might get classroom training on how to assign maintenance tasks for stormwater treatment controls.

Each facility must also implement source control practices that prevent pollutants from coming into contact with rainfall or runoff. Examples include covering a potentially polluting activity, such as a petroleum coke (or other material) stockpile and providing secondary containment for storage of potentially polluting liquids on site. Control practices implemented at a particular site will depend on the facilities and activities at the facility. Examples of source control practices are included in Appendix C, Section B.2.

Where implementation of operational and source control practices at a facility cannot fully prevent contact between pollutants and rainfall or runoff, treatment BMPs must be implemented. Specific treatment BMPs must be selected based on the individual aspects of a facility designed to prevent the discharge of pollutants into the receiving waterbody. Examples of treatment BMPs include the use of porous pavement to allow runoff to infiltrate into the pavement and then into the underlying soil (instead of flowing from the area) and an oil/water separator to separate and treat oil discharges. Examples of treatment BMPs are included in Appendix C, Section B.3.

In addition, a stormwater program must be designed to prevent non-stormwater discharges into the stormwater runoff. For example, polluted water or sewage from other sources could reach a facility through an illegal connection to the stormwater system or by dumping into a storm drain. Holders of a stormwater permit are required to certify that they have implemented a program of observation and testing of potential discharges and have eliminated any discharges.

Finally, the stormwater permit requires implementation of a monitoring program, including observation of visible signs of pollution and sampling of stormwater runoff. Although the stormwater permit requires limited monitoring, an effective program must include comprehensive monitoring both of stormwater runoff onsite and of the receiving waterbody to ensure that the BMPs implemented by the port facilities are effective at preventing pollutants from flowing to the receiving waters. A more complete description of a stormwater monitoring program is included in Appendix C, Section B.5.

In many cases, the surrounding community, environment, and region would be better served if the port improved its land use efficiency instead of expanding its footprint.

It should be noted that circumstances vary greatly from port to port, and this, in turn, has a strong effect on the applicability of specific practices. Users should select practices that best meet overall goals beyond permit compliance, not only preventing discharge from causing or contributing to a violation of water quality standards but also preserving or improving the natural resource values of waters under port jurisdiction. Because BMP effectiveness and feasibility depend on a good match between methods and real-world circumstances at the site, careful selection of approaches is critical.

CONSTRUCTION DESIGN FEATURES TO CONTROL POLLUTION AT PORTS

Design choices can play an important role in reducing pollution from port operations, ranging from a precautionary approach to new port development to targeted pollution control measures employed at existing terminals. At a minimum, to the extent ports expand their operations, they should employ special design features and state-of-the-art technologies to mitigate impacts on the local environment.

Multiple pollution prevention measures should be incorporated into the planning stages of any new port terminal development. Some of the most important mitigation measures for new port terminal development include locating the new terminal near the mouth of the harbor, close to existing transportation infrastructure and far from residential areas. It should be noted, however, that developing on pristine land, and especially filling in waterbodies, should never be sacrificed to meet these criteria. In fact, before expanding, ports must first evaluate whether it is truly necessary. In many cases, the surrounding community, environment, and region would be better served if the port improved its land use efficiency instead of expanding its footprint.

At the very least new terminals should be located away from residential areas to protect communities from the pollution, noise, and other stressful effects of ports' heavy industrial activities. Other measures that must be included in new development include incorporation of infrastructure for cleaner fuels, such as natural gas or even fuel cells; inclusion of on-dock rail in terminal designs; and planning for sufficient electrical power to run equipment and ships that ordinarily run on diesel or bunker fuel.

The location of new terminals near a harbor entrance is a simple way to avoid significant amounts of pollution from ships traveling extra distances from the shipping lanes in the open ocean. For example, the largest single-terminal container complex on the East Coast, at the Port of Savannah, is located 36 miles from the harbor entrance, more than half of which is up a river.[110] The Port of Miami, on the other hand, is located just a few miles from the open ocean.

Multiple pollution prevention measures should be incorporated into the planning stages of any new port terminal developments.

Proximity of new terminals to land transportation infrastructure is also extremely important. Developments that reuse abandoned industrial properties or former military installations are often close to existing highways and main rail lines, and at the same time avoid new construction on a more pristine site. Sufficient roadway infrastructure is important in order to prevent persistent traffic and safety problems on smaller roads. Residents of neighborhoods near busy ports have long complained about trucks cutting through their narrow streets, getting stuck, creating noise and pollution, and causing safety threats to pedestrians and children.

Well-planned railroad infrastructure is particularly important at new port terminals. Although rail transport is environmentally preferable to truck transport, it is still a significant pollution source, and longer, less direct rail lines result in more pollution. Recognizing these issues, the Port Authority of New York and New Jersey is investing $500 million in rail infrastructure to serve its terminals.[111] However, the Port of Charleston failed to consider the impacts of a lengthy rail connection in a recent proposal to build a new container terminal on Daniel Island, a location that would require a circuitous 50-mile rail loop merely to cross a river.[112] Finally, after the state Senate denied the expansion plan, the port was forced to choose a new site for development, on the other side of the river from Daniel Island and close to the existing transportation infrastructure.

On-dock rail, or rails that go all the way onto the docks where ships are unloaded, can significantly reduce pollution by eliminating the need for truck trips to shuttle containers from the docks to a rail yard. Increasingly, ports are embracing on-dock rail as a means to increase efficiency. The recent container terminal development at the Port of Seattle was built with on-dock rail, routing the majority of containers out via rail rather than truck. The Port of Seattle reports that on-dock rail, combined with other rail improvements, has replaced 200,000 miles of truck trips in Seattle annually.[113]

OTHER MEASURES TO ALLEVIATE IMPACTS FROM PORT OPERATIONS

Ports need to consider many other measures in addition to those that mitigate air and water quality impacts. Following are short descriptions of measures that abate traffic, noise, and aesthetic impacts. This list is not intended to be comprehensive. Many more mitigation measures may be necessary to address impacts on specific communities near marine ports. However, this list is representative of the concerns commonly raised by nearby communities.

Traffic Mitigation Plan

Ports should create and implement a traffic mitigation plan. Ports should conduct a study of traffic on roads and highways in and around the port and then create and implement a meaningful traffic plan based on the findings to reduce congestion and impacts from the port on local roads and highways. Although traffic studies are required for expansion projects, it is important that ports study existing traffic to reduce the impacts from prior port growth. Public comment and input should be a priority throughout the process.

Minimize Noise and Light Pollution

Ports should minimize noise and light pollution. Because ports are often close to residential areas, their highly industrialized operations create a number of hazards and nuisances for nearby communities. Ports should make every effort possible to

A FINNISH MODEL: THE VUOSAARI HARBOR PROJECT

The Vuosaari Harbor Project is an ambitious new development that will move all of Helsinki's port operations out of the downtown area to the Vuossari Harbor. The project may be the best example of a new port development that employs precautionary measures.

Construction recently began on the new terminals, at a total cost of more than $550 million to relieve downtown Helsinki from the pollution, noise, and traffic from its port operations. The core operations of the harbor will be 2 kilometers from the nearest residential area. The new development, however, is very close to designated natural habitat areas, and therefore a number of mitigation measures have been employed.

Most notably, plans call for rail and road tunnels, and a special bridge to be built, in order to avoid disturbing certain sensitive wildlife areas. Bridge and tunnel designs incorporate various elements that will minimize noise, vibration, and the potential for hazardous spills and water contamination. The rail tunnel will be electrified, and the rail bridge will incorporate warning devices to prevent birds from flying into the cables. Outside of the tunnels and bridges, the rail and road corridor will be adjacent to noise barriers and native landscaping. Other measures include bicycle paths and footpaths, several foot bridges, noise shielding and native landscaping of the rail yard and harbor road, and groundwater monitoring.

Sources: Port of Helsinki, *Vuosaari Harbour is Important for the Foreign Trade of the Whole of Finland*, Port of Helsinki: Helsinki available at http://www.vuosaarensatama.fi/fi/index.html. Port of Helsinki, *Harbour centre-vitality for the development of Vuosaari and its environs. Sustainable Port Development: case: Port of Helsinki/Vuosaari harbour*, in Sustainable Port Development. 2002, Genoa.